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Canada/NB MDA Project on Mine-shaft Rope Testing; testing of $2\frac{1}{4}$ in., 34×7, NR, T. R., (our rope #11)

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CANADA/NB MDA PROJECT ON MINE-SHAFT ROPE TESTING; TESTING OF $2\frac{1}{4}$ in., 34×7, NR, T. R. (OUR ROPE #11)

by

L.B. Geller*, D. Poffenroth†, J.E. Udd**, and D. Hutchinson††

ABSTRACT

In this report the authors analyse the test-results obtained non-destructively on a $2\frac{1}{4}$ in. diameter, 34×7, spin-resistant/non-rotating (NR) tail-rope (T.R.). The rope was only examined in-situ as part of CANMET's project to comparatively evaluate the performance of a range of EM wire-rope testers. This is the first time that a project of this magnitude and diversity has been undertaken.

The rope was tested with the Canadian Magnograph and Rotescograph, as well as with the American LMA-250, and with the German WBK instruments. The maximum estimated strength-loss (LBS) was reported as being 6.8% by the Rotescograph operator. The operators of the other instruments did not submit LBS estimates.

Within the context of CANMET's present project it was intended to only test ropes that were in a bad, or very bad, condition. In this context the condition of our rope #11 was too good. However, the results are of interest because: (a) they were obtained on the largest diameter rope included in CANMET's present project, (b) the total rope-length could only be tested with two instrument set-ups, and (c) this was the only field-test in the present project that included the German WBK instrument as well.

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Keywords: New Brunswick; Mineral Development Agreement; Wire-ropes; Non-destructive-testing; Electro-magnetic instruments; Hoist-ropes; Spin-resistant/Non-rotating ropes

EEM CANDA/NB SUR L'ESSAI DE CÂBLE DE PUITS DE MINE; ESSAI D'UN CQ-NT, 34×7, DE $2\frac{1}{4}$ PO (NOTRE CÂBLE NO 11)

par

L.B. Geller*, D. Poffenroth†, J.E. Udd**, et D. Hutchinson††

RÉSUMÉ

Dans le présent rapport, les auteurs analysent les résultats d'essais non destructifs effectués sur un câble queue (CQ) antigiratoire (AG), résistant à la torsion, 34×7, de $2\frac{1}{4}$ po de diamètre. Le câble a été seulement examiné in-situ dans le cadre du projet de CANMET visant à comparer les rendements de divers appareils ÉM d'essai des câbles métalliques. C'est la première fois qu'un projet de cette ampleur et de cette diversité est entrepris.

Le câble a été vérifié à l'aide du Magnograph et du Rotescograph de fabrication canadienne, du LMA-250 américain, et du WBK allemand. La perte de résistance (LBS) maximale a été estimée à 6.8% et 7.0% par l'opérateur du Rotescograph. Les opérateurs des autres l'instruments n'ont pas fourni d'estimations.

Le présent projet de CANMET avait pour seul but de vérifier des câbles en mauvais ou très mauvais état, de sorte que l'état du câble no 11 à l'essai était en trop bonne condition. Cependant, les résultats sont intéressants parce que: (a) ils se rapportent au plus gros câble à l'étude dans le projet de CANMET, (b) la longeur totale des câbles n'a pu être vérifiée qu'avec deux montages d'instruments, et (c) il s'agissait du seul essai sur le terrain prévu dans le projet qui faisait aussi intervenir le WBK instrument allemand.

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Mots clés: Nouveau-Brunswick; Entente sur l'exploitation des minéraux; câbles métalliques; essai non destructif; instruments électromagnétiques; câbles de levage, câbles antigiratoires résistants à la torsion

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BACKGROUND

The results described in this report constitute an integral part of the contracted phase of CANMET's project, undertaken in 1986 in response to requests by both the mining industry and the mine regulatory authorities. The basic project objectives specified that the continuing rope failures, or near failures — occurring despite mandatory wire-rope examinations with electro-magnetic (EM) instruments at regular intervals — be examined, documented, analysed, and the reasons for these occurrences clarified. This is the first time a project of this scope and depth has been undertaken, anywhere.

CANMET's work included both in-house and contracted work phases. The in-house phase resulted in a range of conclusions and recommendations, reported elsewhere (references 1 through 6). We are now in the process of reporting the results obtained during the contracted project-phase, which included an extensive series of both in-situ and shop-floor tests. The first seventeen reports to describe this project phase were prepared in the period February, 1990, through June, 1991 (references 7 through 23). More are to follow.

ROPE DETAILS

The rope of current interest (referred to as "our rope #11") was designated #2 (of two) Tail Rope in Shaft #3 (skip and counterweight) of Bell Asbestos Mines Ltd., at Thetford Mines, Quebec. Its reel number was 446900-1. It measured $2\frac{1}{4}$ in. diameter, and was of a 34×7, NR, construction, right Langs lay, with nylon core. It was installed on 1986 10 26*. It was still in use at the time Phase I of CANMET's project on comparative evaluation of EM wire rope testers was concluded.

Unfortunately, we do not have any further information about the operational background of this rope, or of its companion rope. The skip-counterweight (ctwt) assembly in question was operated by four $1\frac{3}{8}$ in., 1×147 FLC head-ropes, with two $2\frac{1}{4}$ in., 34×7 tail-ropes.

*: dates are given in this order: year, month, day

IN-SITU TEST RESULTS — AS REPORTED AND REVIEWED

The Magnograph data

The operator reported (report #89-323B) having tested, on 1989 04 15, a rope length of 1,494 ft (Fig. 1). Testing started at the skip rope-end. An LMA_{max} of 6.0% was reported, some 936 ft from start of the test. The presence of one broken wire was also noted.

No loss-of-breaking-strength (LBS) estimates were submitted. The operator commented that, due to fairly severe internal corrosion, the presence of some of the broken wires was masked. Interestingly, for the companion tail-rope, the operator also reported (report #89-323A) an LMA_{max} of 5.0%. Moreover, here the presence of two or three broken wires at each of two different locations was noted, and the masking effect of the internal corrosion commented upon.

The operator used two test set-ups. Unfortunately, we were unable to check the accuracy of the reported LMA chart-readings, because: (1) no marker was used in the overlapping rope-section, at any rate none that would have shown up on the strip-chart traces, and (2) the LMA trace on the chart submitted to us was so faint that its exact location could not be reconstructed accurately.

All told, we believe that the reported LMA chart-readings are in excess of the 'true' ones, due: (a) to difficulties with accurate chart-alignment and splicing procedures, and (b) due to possible instrument calibration problems.

The LMA-250 data

The operator reported having tested a rope length of some 1,310 ft (Fig. 2) on 1989 04 07. Testing started at the skip rope-end. The 0.0% LMA reference level was placed at the counterweight rope end. An LMA_{max} of 3.5% was reported. No LBS estimates were submitted.

Two test set-ups were used. The two strip-chart segments were aligned and spliced together with the help of a tape-mark on the rope. Unfortunately, this marker did not show up on the LF and LMA chart-traces.

We agree with the reported data, *per se*.

The Rotescograph data

The operator tested some 1,240 ft of rope on 1989 04 07 (Fig. 3). Testing started at the skip rope end. Two test set-ups were used. The LMA chart-readings were recorded on the strip-charts. The operator also noted the presence of minor corrosion. Moreover, the operator submitted LBS estimates. These were obtained by doubling the corresponding %LMA chart-readings.

While we agree with the operator's individual chart-readings *per se*, we can not accept these readings for the rope as an entity, because the operator treated the two chart-segments (obtained at the skip and at the counterweight rope ends) as if these belonged to two, independent, rope-lengths. No attempt was made to align and splice them together. In fact separate 100% reference levels were used for the two rope-segments.

We aligned and spliced together the two segments ourselves (Fig. 3c). Moreover, we added the 100% reference level and the LMA_{max} value of 3.9% to Fig. 3c. Interestingly, our chart-readings in Fig. 3c agree well with the LMA-250 data, as reported by the latter instrument's operator (Fig. 2).

The WBK data

In-situ testing was performed on 1989 04 07 with the German WBK instrument. The rope length tested was only 1,004 ft (306 m), because the operators tested the counterweight rope-end only, and not the entire rope-length. They did not undertake the second instrument set-up that would have been necessary to test the complete rope-length.

The strip-chart contains, reading from top-to-bottom: five LF traces, a %LMA trace, and a length indication scale (in meters). There is also space for a second %LMA trace and for a rope-diameter indication-trace (not used in the current test-series). With the sensor-head closed, the individual measuring coils LF #1 and LF#2 were joined together, and so were #3 and #4. The fifth LF chart-trace summarizes the output of these two individual traces. Defects, such as the anomalies 'X' and 'Y', were conspicuous on the LMA chart-trace.

The two WBK operators carefully annotated their chart, including some LMA readings. They also submitted a report. Testing commenced at the counterweight rope-end. There was no LMA difference between the two rope-ends.

We did not receive a copy of the complete strip-chart. Instead, copies of a number of chart sections were submitted, numbered Figures S.1 to S.22, inclusive. We reproduce these as our Fig. 4. As may be seen, the 0.0% LMA reference level was set along the counterweight rope-end; the %LMA scale was 0.213% per mm of full-scale diagram (see 'Fig. S.21' of our Fig. 4). We added our own marking of the %LMA chart-readings at the characteristic rope-anomalies 'X', and 'Y'. Test results are tabulated in Table 1.

We agree with the operators' report, *per se*. We can not, however, accept these results for the rope as an entity, because the operators did not test the entire rope-length. In our opinion their report should have contained appropriate comments to this effect. In this context we may add that the same operators submitted a report on test-results, as obtained on our rope #4. Here too, testing of the entire rope-length necessitated two test set-ups. While this was done, the operators treated the two rope-segments as if they were independent of each other, basing their chart-readings on two separate 100% reference levels.

DESTRUCTIVE TESTING

This rope was still in use at the time of completion of CANMET's present project, Phase I. We could not, therefore, obtain samples for destructive testing.

ANALYSIS OF TEST RESULTS

(1) General comments

Considering the influence of the instrument calibration-procedures upon the test-results, we included relevant information about these matters in Table 1, such as: (a) the rope-end at which calibration was effected, (b) the rope-segment at which 0.0%LMA was found to be, and (c) the %LMA difference between the two rope-ends.

Wherever we were unable to reproduce the strip-charts in a single length, we provided match-marks (such as ref. 'A'; ref. 'B'; etc.) on the individual chart-segments. Moreover, we added to all charts: (a) the 100% reference levels, (b) the relevant sensitivity scales (%LMA per major chart-division), and (c) the LMA_{max} chart-readings. It should be noted that the entire rope length of our rope #11 could only be tested with two instrument set-ups.

The rope was in a relatively good condition. The major interest in examining it was due to the fact: (1) that it was the largest rope diameter tested within the framework

of CANMET's project on comparative evaluation of EM wire-rope testers, (2) that it was the only in-situ test within this project involving the German WBK instrument, and (3) that testing of the entire rope-length involved two instrument set-ups.

Details of the test set-ups are listed in Table 2.

(2) LMA chart readings

We tabulated the %LMA chart-readings in Table 1. We agree with the reported values, *per se*. We do, however, note that the Rotescograph operator, mistakenly, treated the two strip-chart segments as separate entities, and that the WBK operators only tested an incomplete rope-length. We can not, therefore, accept these results as valid ones for the rope as an entity.

Comparative evaluation of the four EM instruments used can, perhaps, be best based on the $\%LMA_{max}$, as well as on the %LMA chart-readings at the characteristic rope-anomalies 'X', 'Y', and 'Z' (Table 1). These are in fair agreement, apart from the Magnograph results. As explained previously, we suspect the latter to be excessive due to problems with: (a) chart-alignment and splicing, and (2) possibly also with instrument calibration.

The chart-alignment and splicing accuracy-problems were due, primarily, to the absence of an appropriate rope marker trace on the strip-charts, within the overlapping rope section.

Although our rope #11 was the largest diameter tested within CANMET's project of current interest, results in Table 1 indicate that all instruments performed equally well. Differences in the LMA chart-readings were, in our opinion, due to operator, rather than instrument related problems.

(3) LF chart readings

Broken wires were not of major significance. Corrosion, too, was described as being from minor to medium severity only.

(4) LBS estimates

Since we did not perform any destructive rope testing, we had no way of checking the accuracy of the Rotescograph operator's LBS estimate.

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APPENDIX

Tables 1 and 2

as well as Figures 1 through 4, inclusive

Table 1

In-situ test-results

Subject	Magnogr. 1989 04 15 Fig. 1	LMA-250 1989 04 07 Fig. 2	Rotescogr. 1989 04 07 Fig. 3c	WBK 1989 04 07 Fig. 4
tested rope length	1,494 ft	1,310 ft	1,240 ft	1,004 ft**
Max. %LMA: @ ft*	6.0% 558 ft	3.5% 110 ft	3.9%† 55 ft	4.1% 69 ft
0.0% LMA @:	ctwt end	skip end	skip end	both ends
calib. @: skip; ctwt;	yes —	yes —	yes —	— yes
%LMA diff. betw. ends:	3.0%	1.5%	1.0%	0.0%
%LMA @: 'X' 'Y' 'Z'	3.5% 4.5% 6.0%	2.9% 3.4% 3.0%	3.0% 3.6% 3.2%	3.1% 4.1% 3.4%

*: from the counterweight (ctwt) rope-end

**: skip rope-end segment not tested; operators did not undertake the necessary second test set-up

†: vs 2.2% (see Fig. 3a) and 3.4% (see Fig. 3b), as reported by the operator

Table 2

Details of EM testing of the $2\frac{1}{4}$ in., 34×7, NR, T.R.

Item No.	Test Instr.	Test No.	Test date	Test location	Instr. operator*	Test chart: Fig. #
1	Magnograph	#89-323B	1989 04 15	in-situ	(2)	1
2	LMA-250	—	1989 04 07	in-situ	(5)	2
3	Rotescograph	ME-0014RPN & -0015RPN	1989 04 07	in-situ	(6)	3
4	WBK	—	1989 04 07	in-situ	(7)	4

*: (7): instr. designer/maker and service company

(2) service company

(6): mining company

(5) government organization

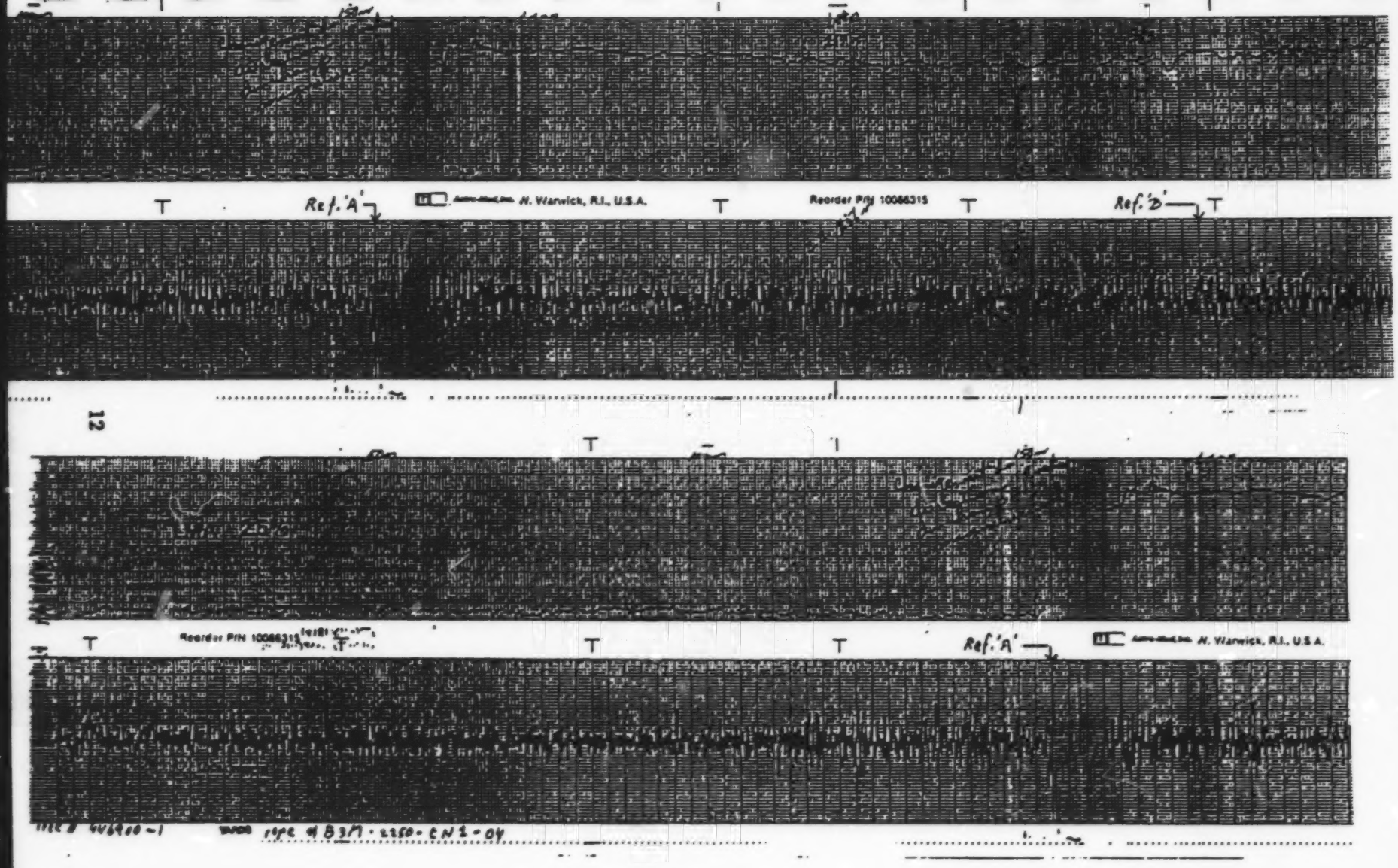

Fig. 1a — Magnograph test, in-situ, of 1989 04 15; as reported

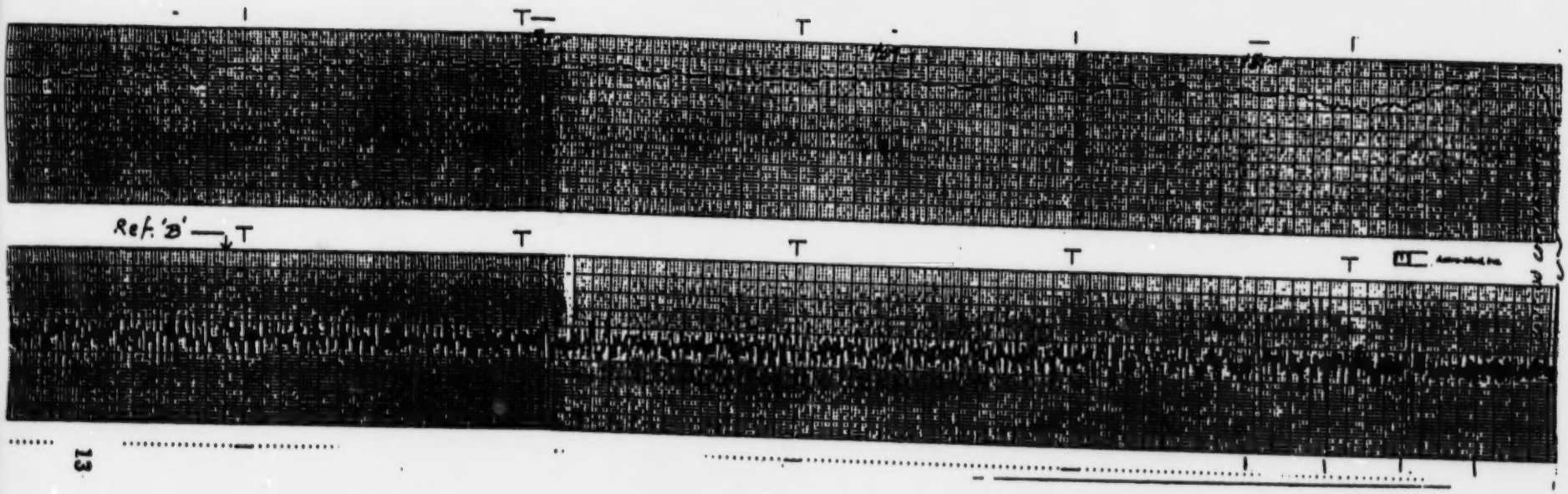

Fig. 1a (continued) — Magnograph test, in-situ, of 1989 04 15; as reported

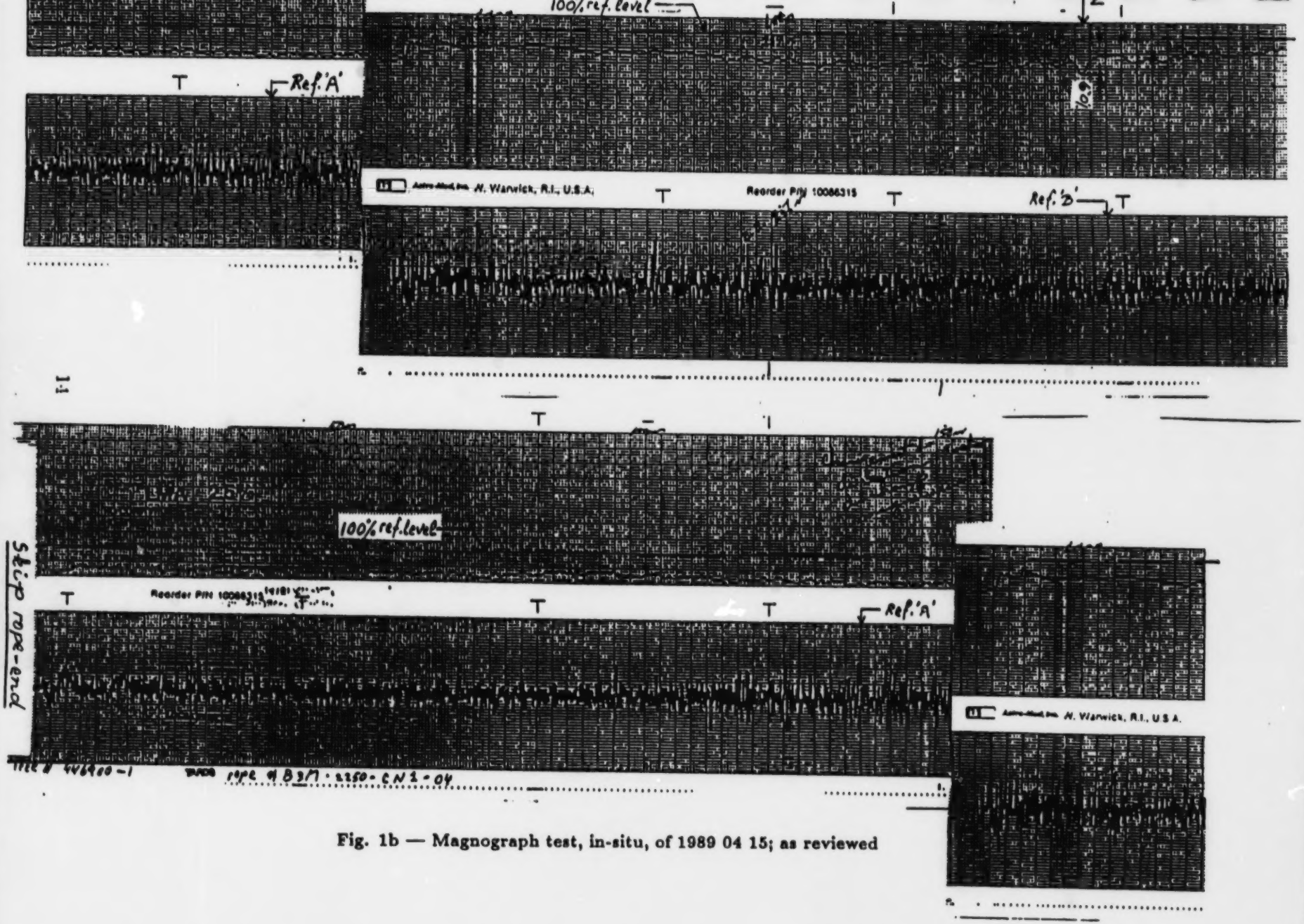

Fig. 1b — Magnograph test, in-situ, of 1989 04 15; as reviewed

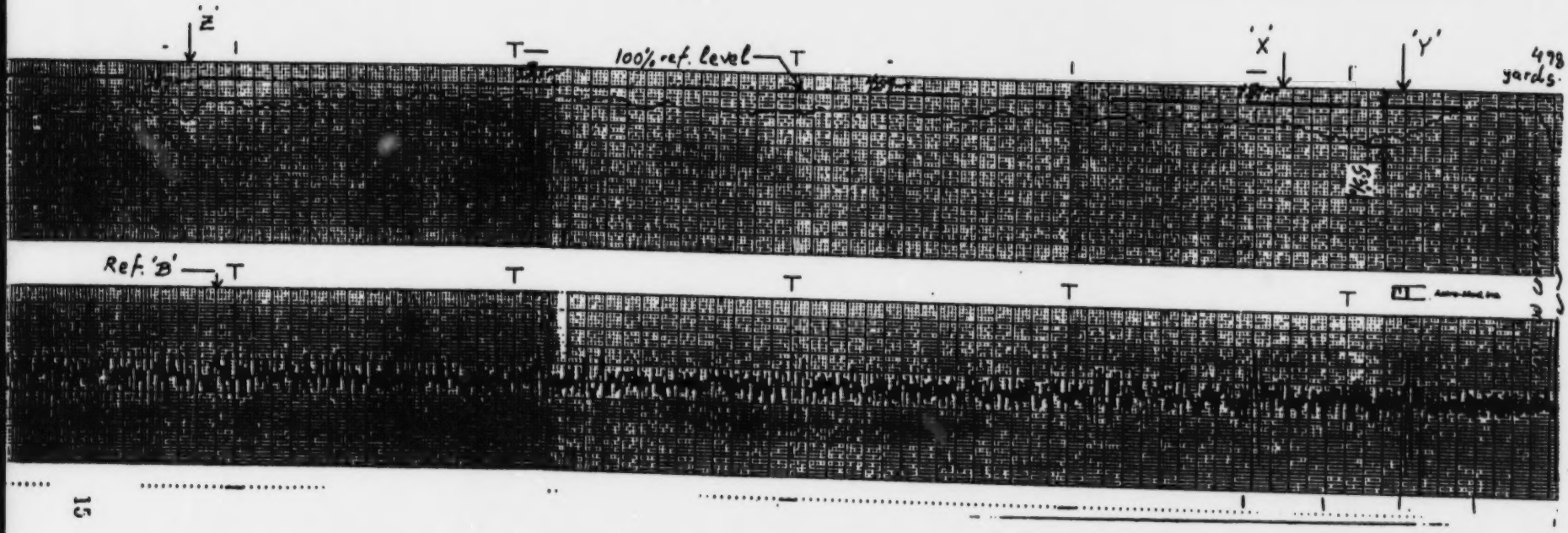

Fig. 1b (continued) — Magnograph test, in-situ, of 1989 04 15; as reviewed

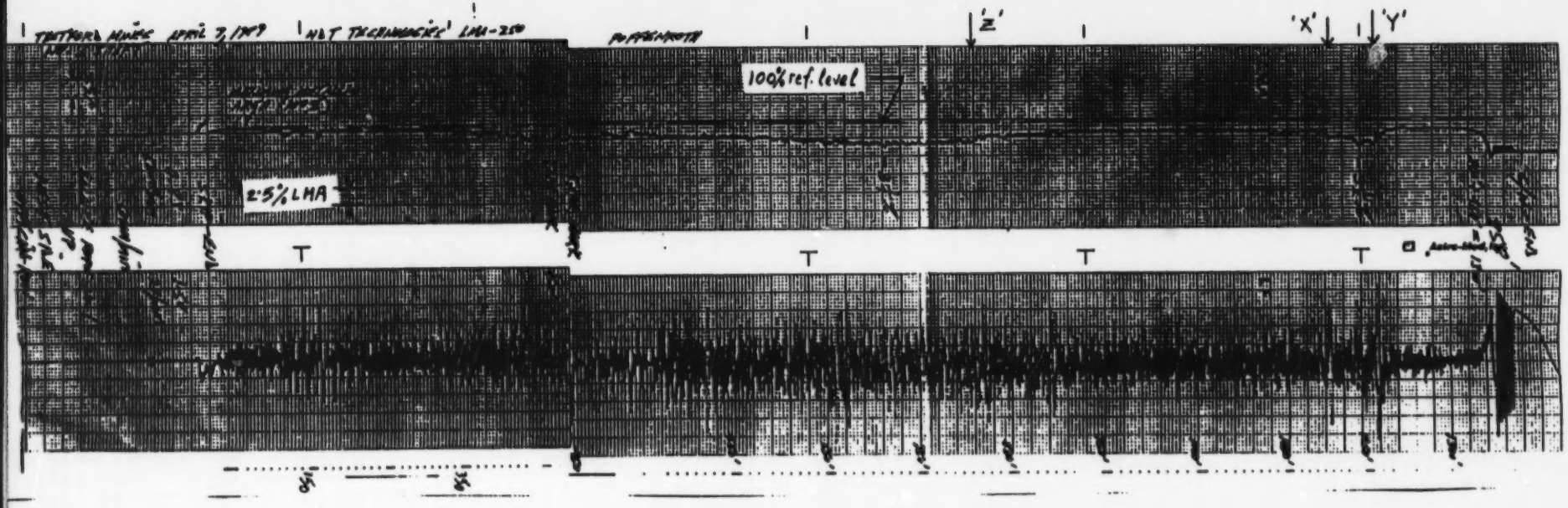

Fig. 2 — LMA-250 test, in-situ, of 1989 04 07; as reported and reviewed

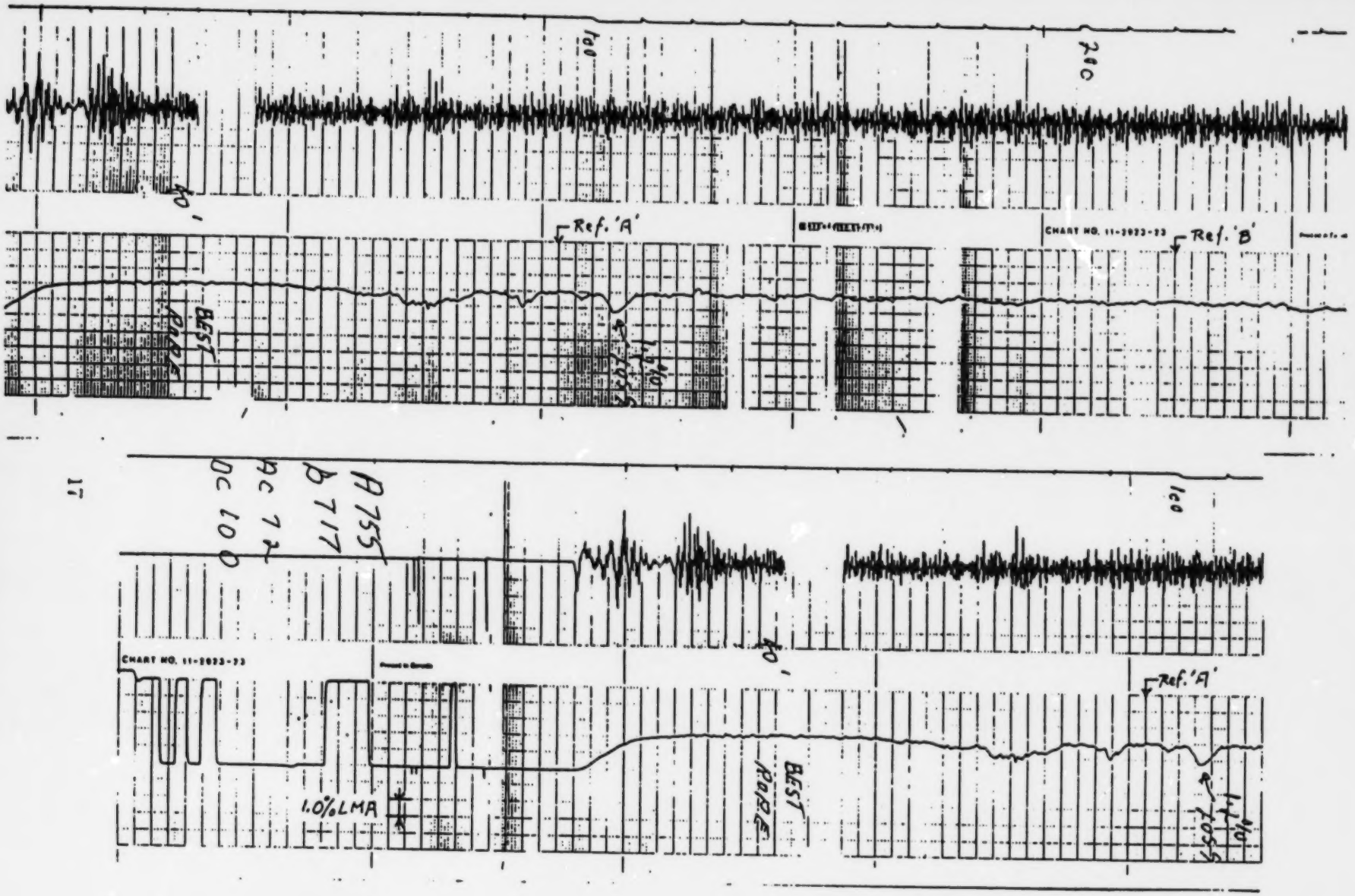

Fig. 3a — Rotescograph test, in-situ, of 1989 04 07; skip rope-end, as reported

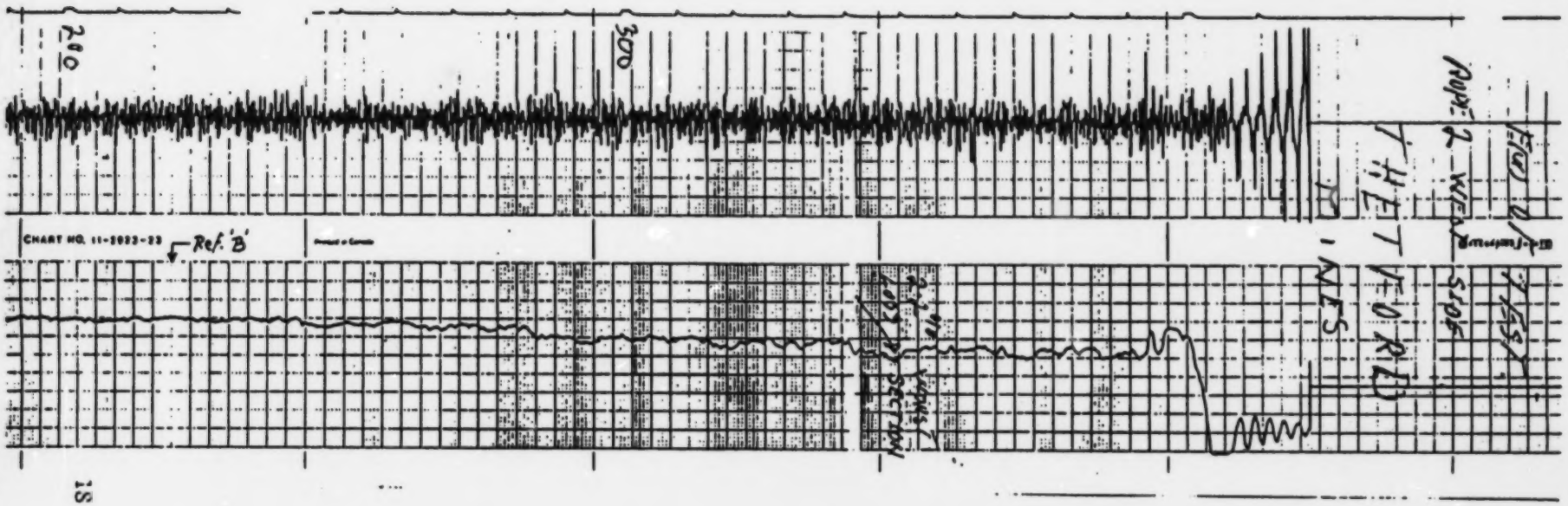

Fig. 3a (continued) — Rotescograph test, in-situ, of 1989 04 07; skip rope-end, as reported

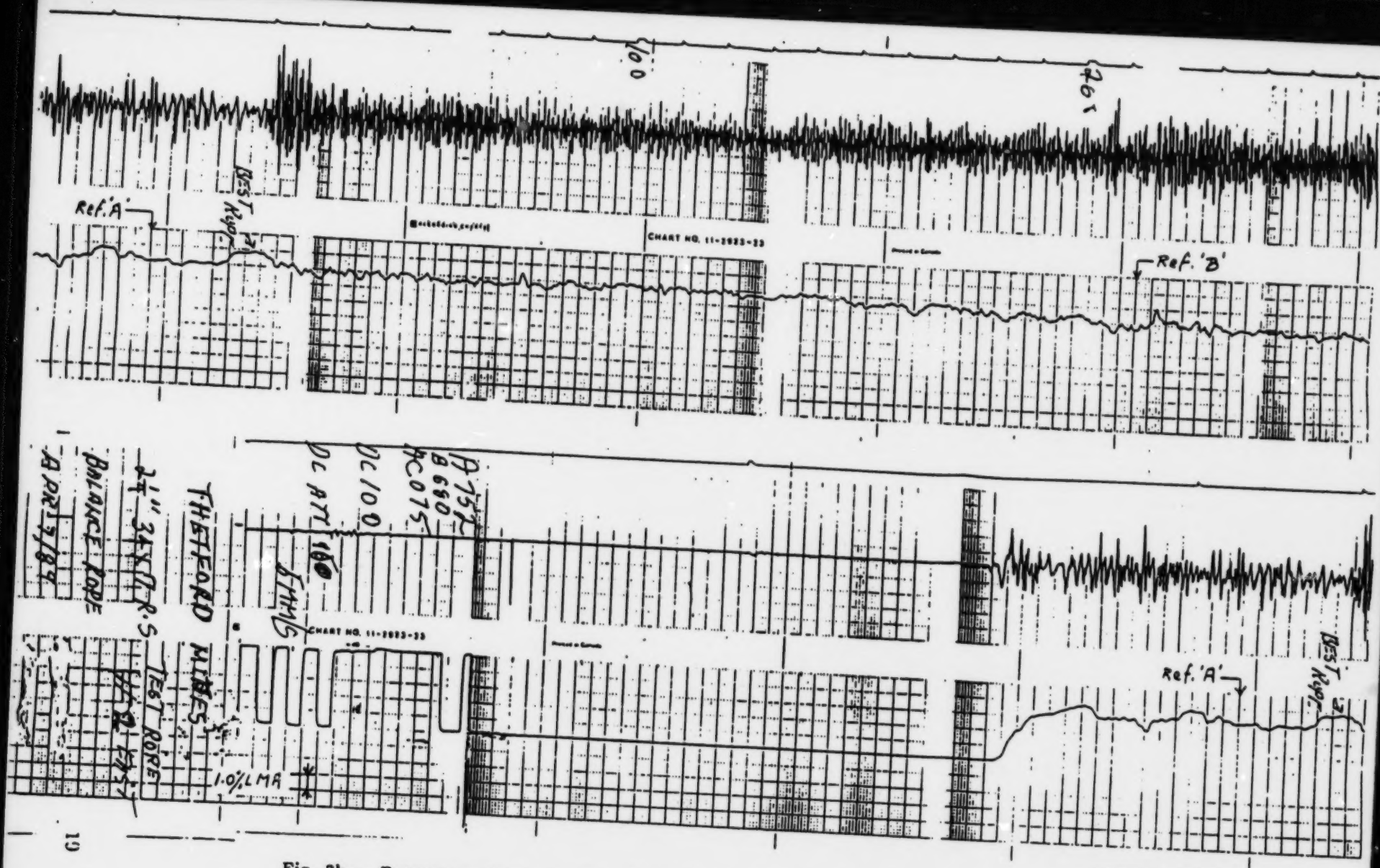

Fig. 3b — Rotescograph test, in-situ, of 1989 04 07; counterweight rope-end, as reported

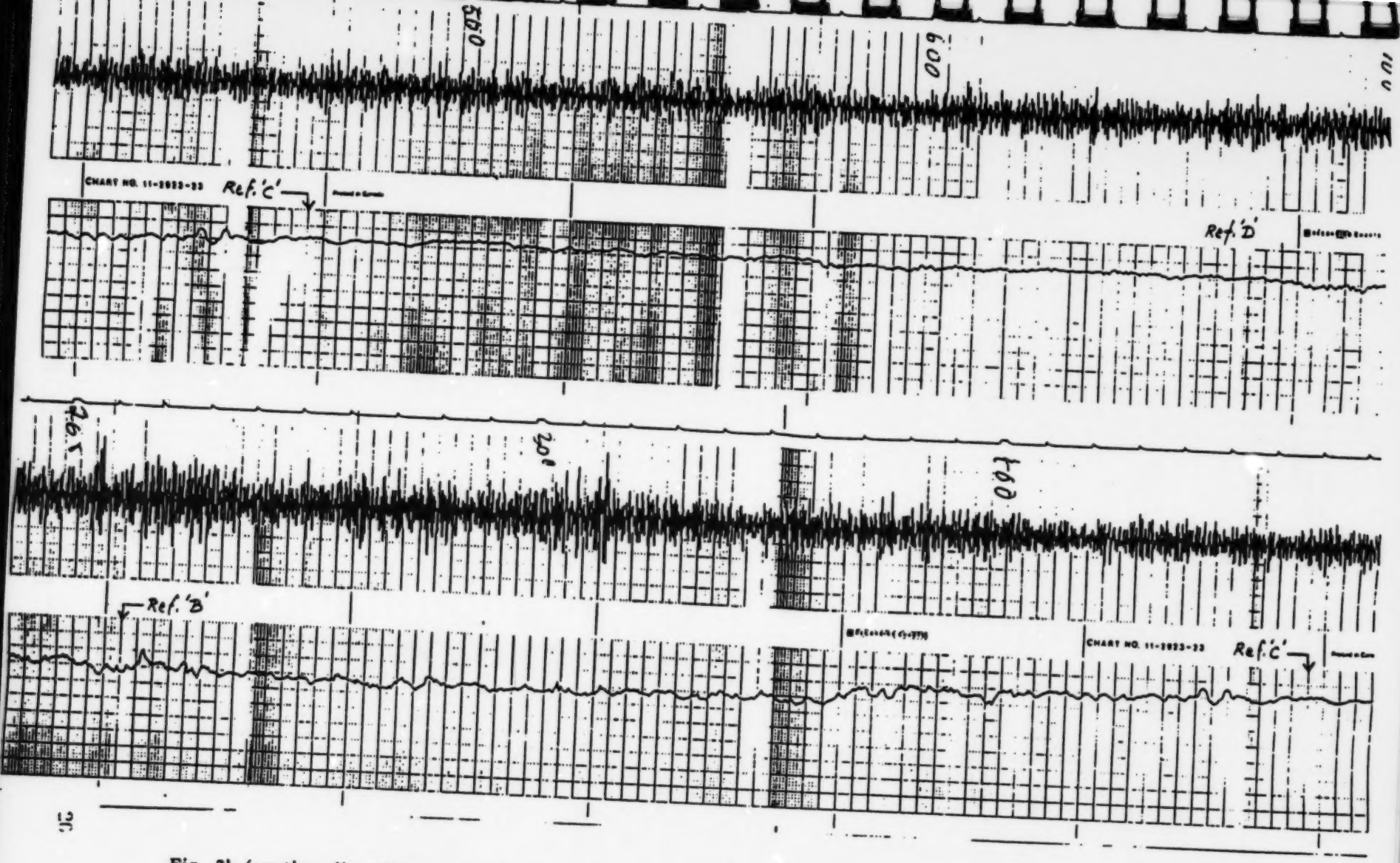

Fig. 3b (continued) — Rotescograph test, in-situ, of 1989 04 07; counterweight rope-end, as reported

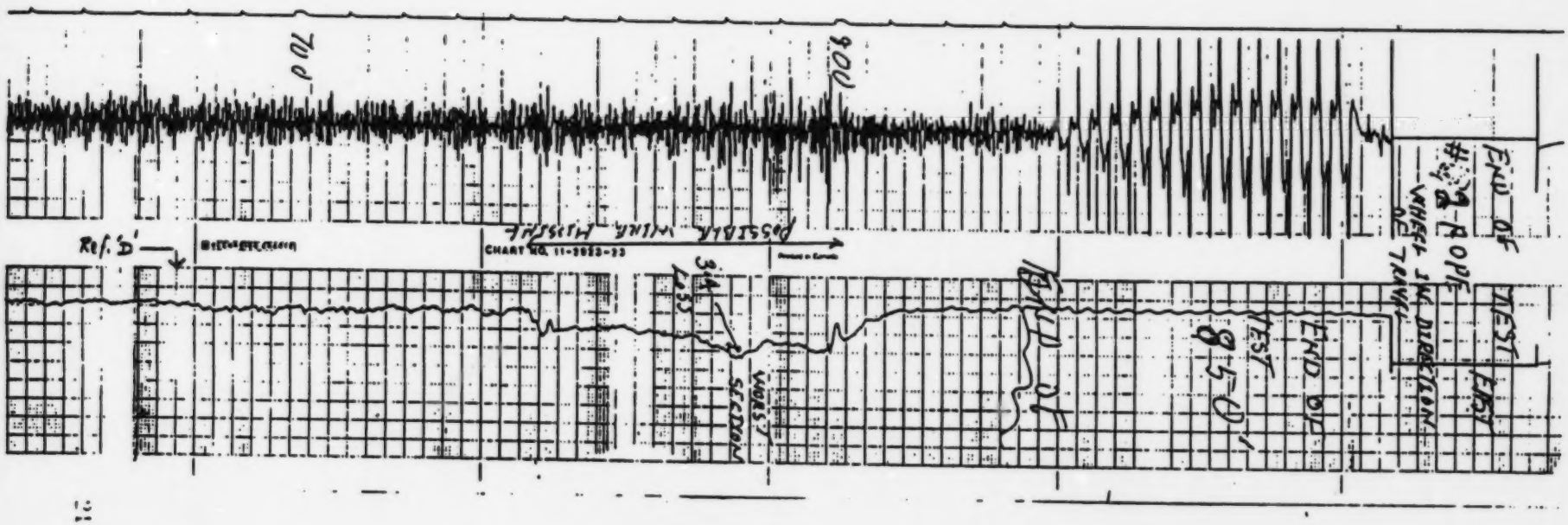

Fig. 3b (continued) — Rotescograph test, in-situ, of 1989 04 07; counterweight rope-end, as reported

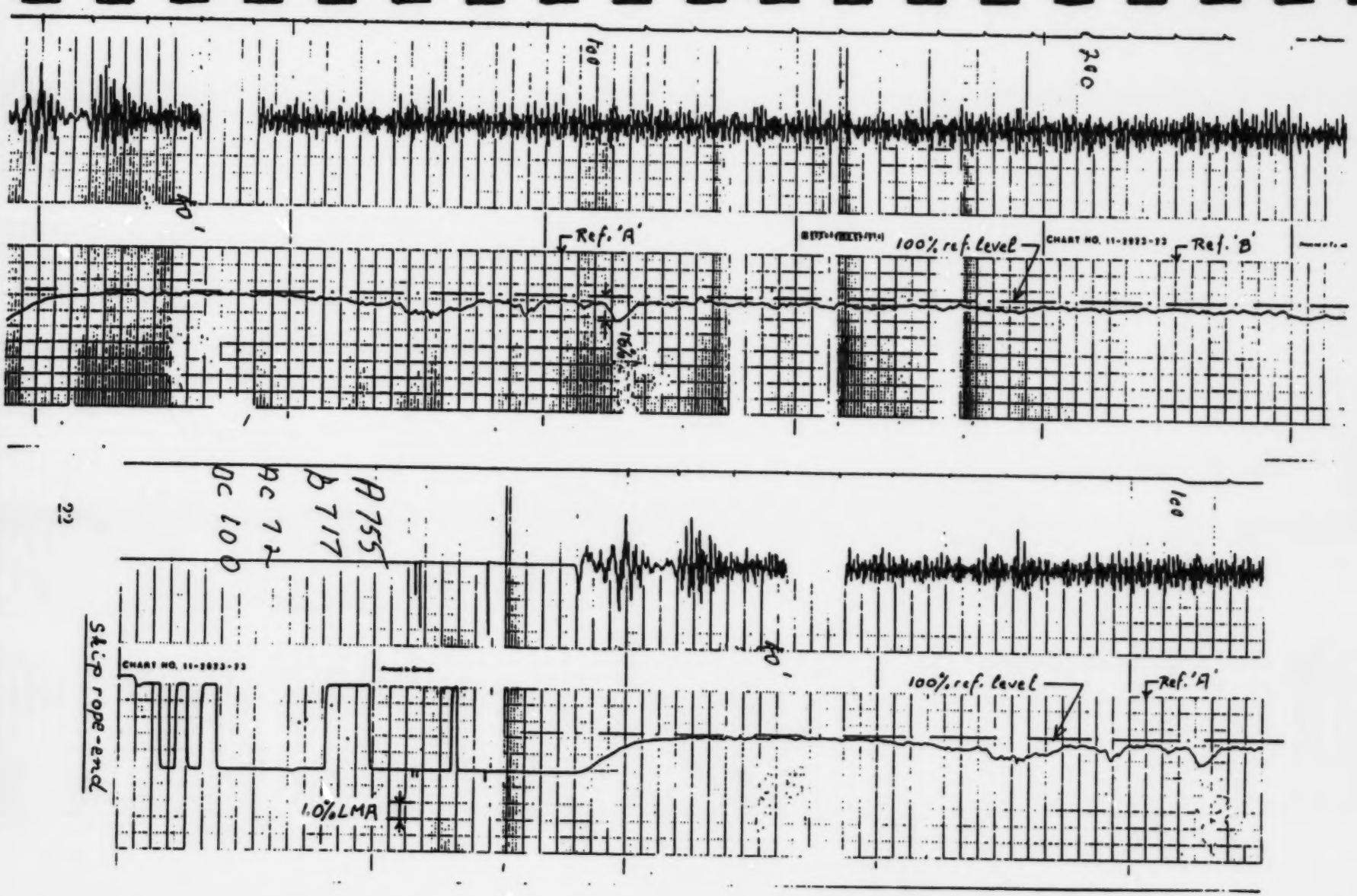

Fig. 3c — Rotascograph test, in-situ, of 1089 04 07; total rope length, as reviewed

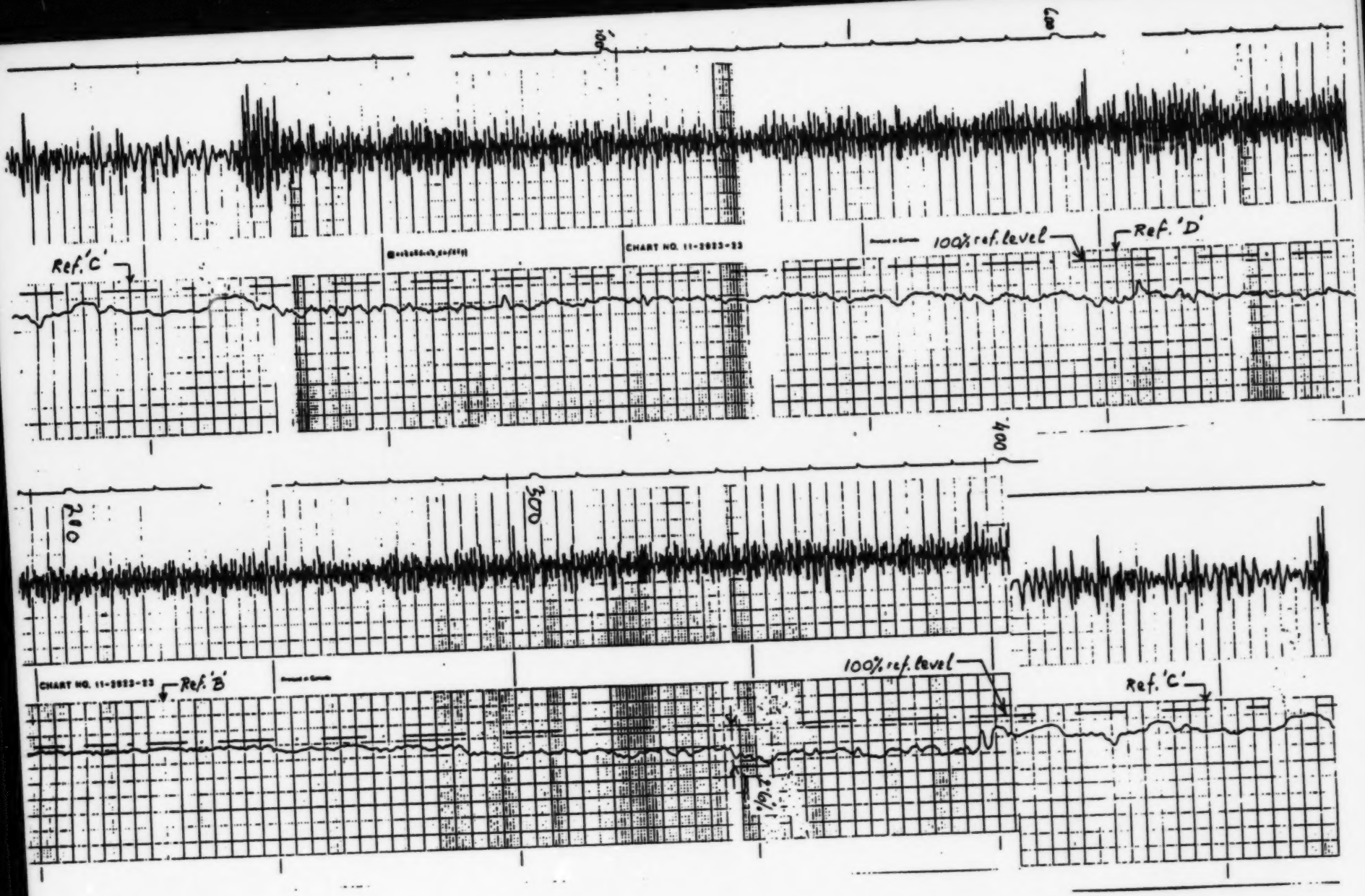

Fig. 3c (continued) — Rotescograph test, in-situ, of 1989 04 07; total rope length, as reviewed

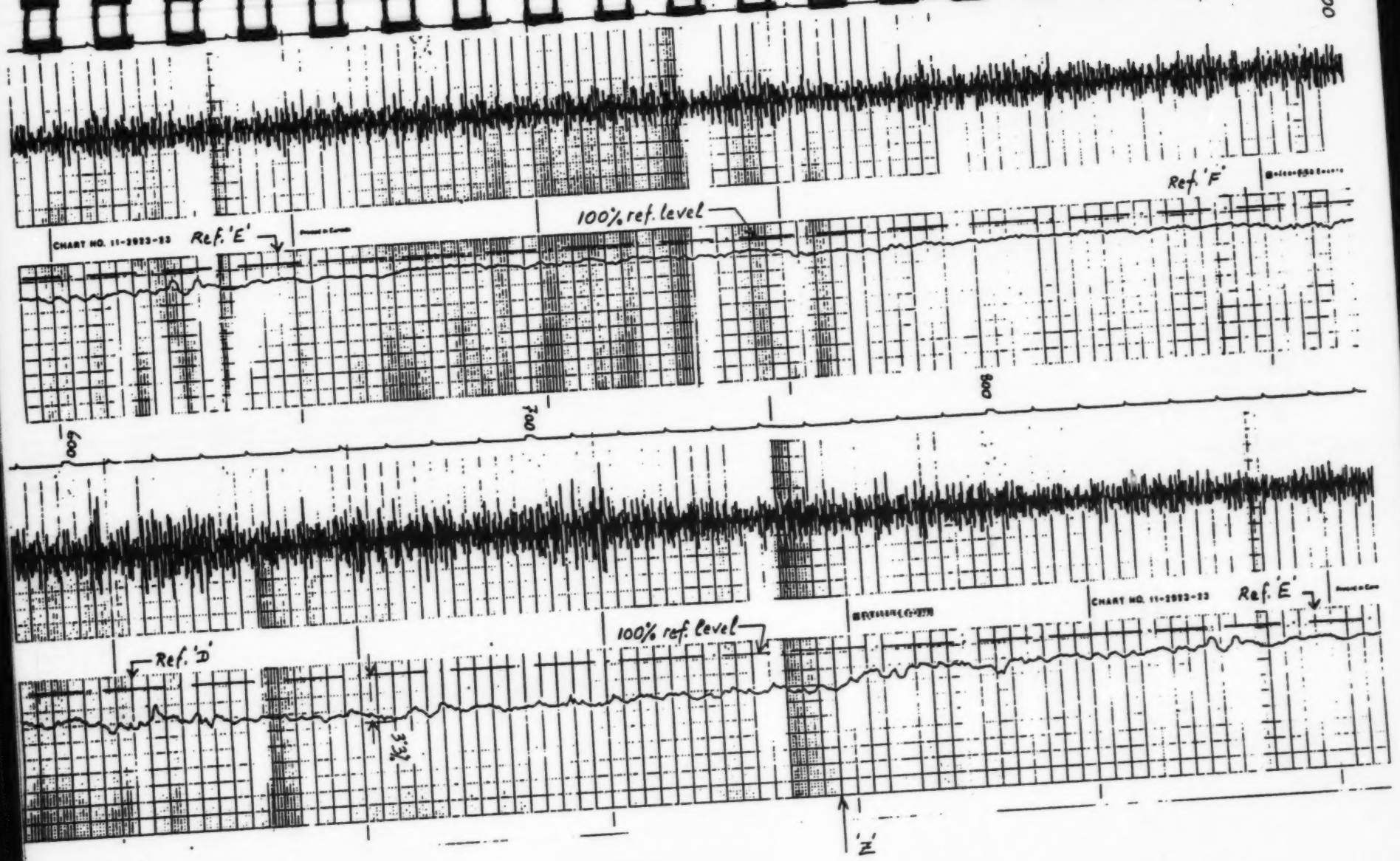

Fig. 3c (continued) — Rotoscograph test, in-situ, of 1980 04 07; total rope length, as reviewed

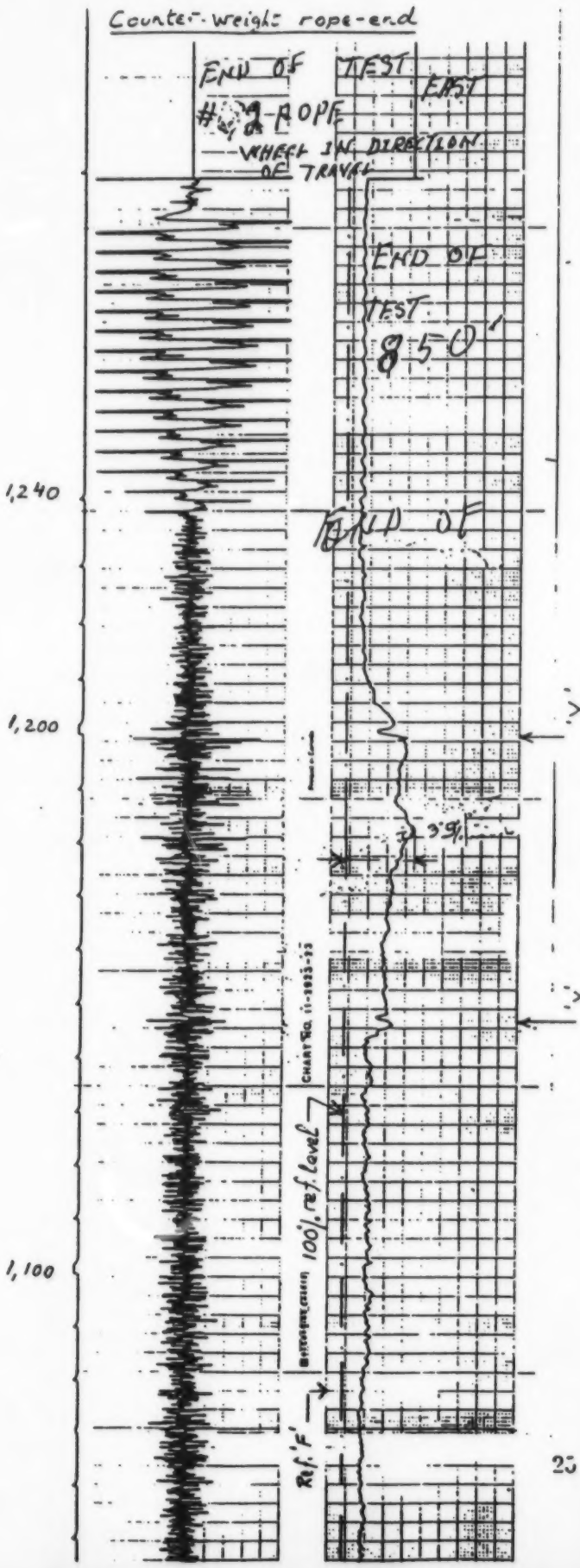

Fig. 3c (continued) — Rotescograph test, in-situ, of 1989 04 07; total rope length, as reviewed

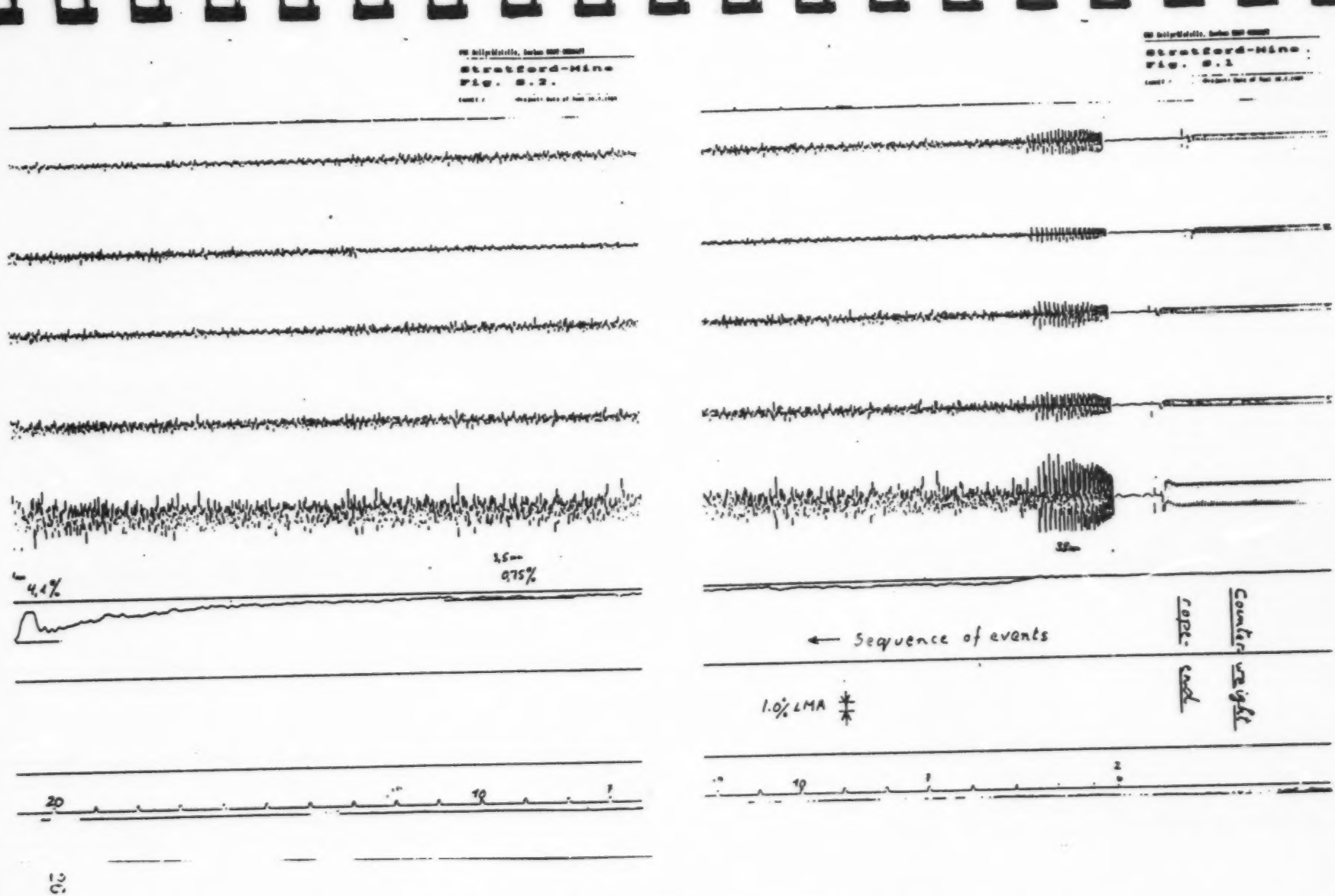

Fig. 4 — WBK test, in-situ, of 1989 04 07; as reported and reviewed

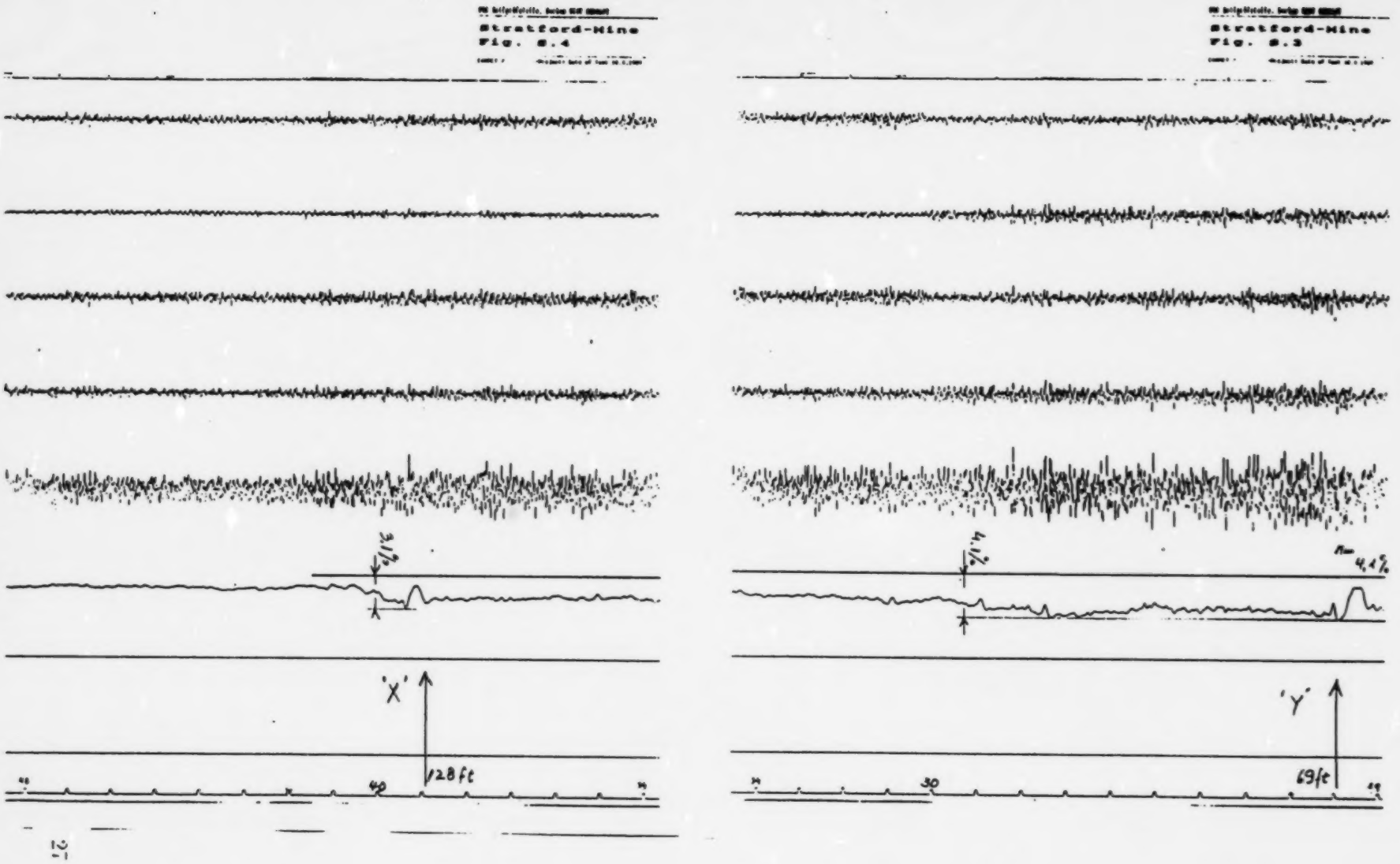

Fig. 4 (continued) — WBK test, in-situ, of 1989 04 07; as reported and reviewed

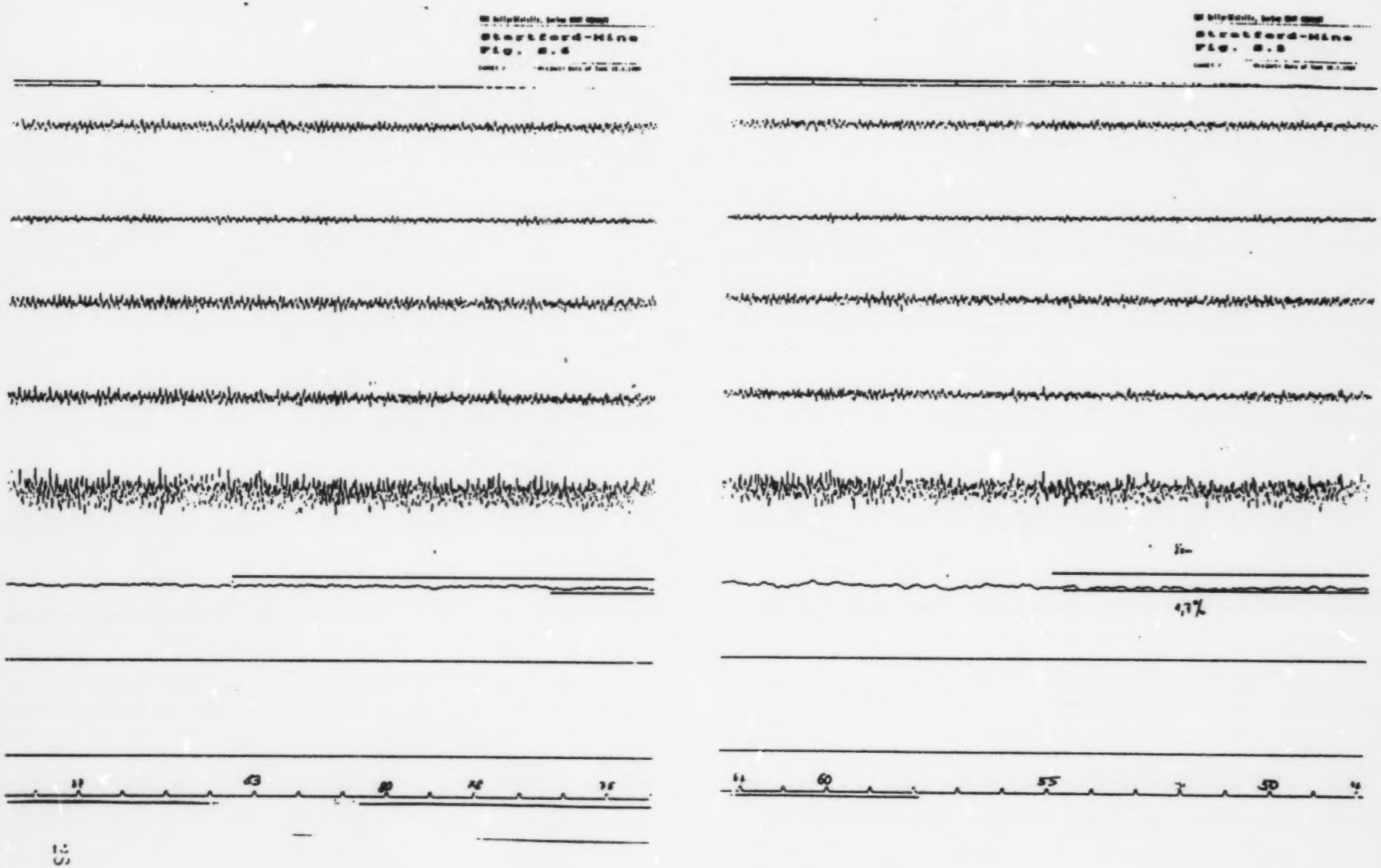

Fig. 4 (continued) — WBK test, in-situ, of 1989 04 07; as reported and reviewed

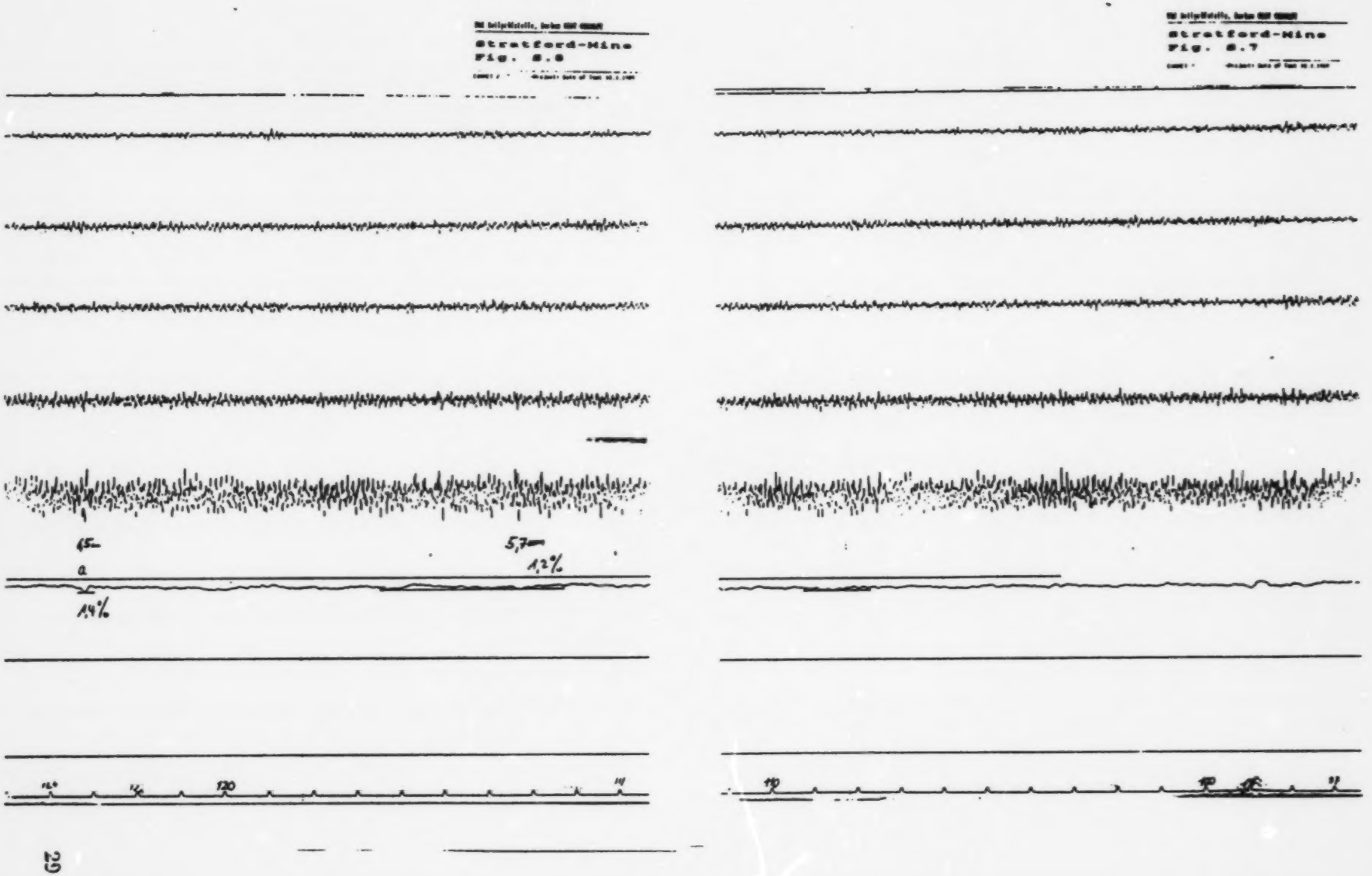

Fig. 4 (continued) — WBK test, in-situ, of 1989 04 07; as reported and reviewed

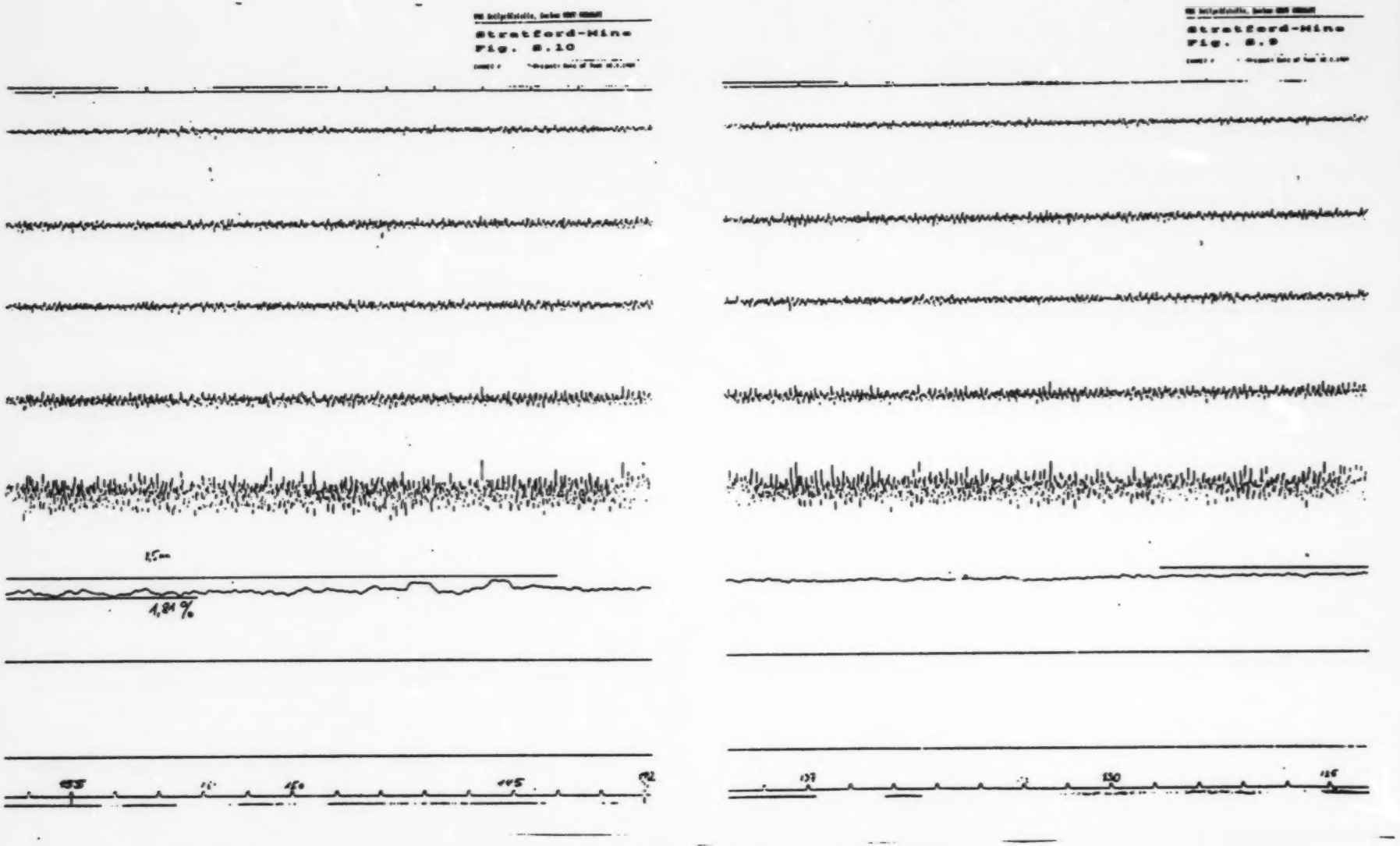

Fig. 4 (continued) — WBK test, in-situ, of 1989 04 07; as reported and reviewed

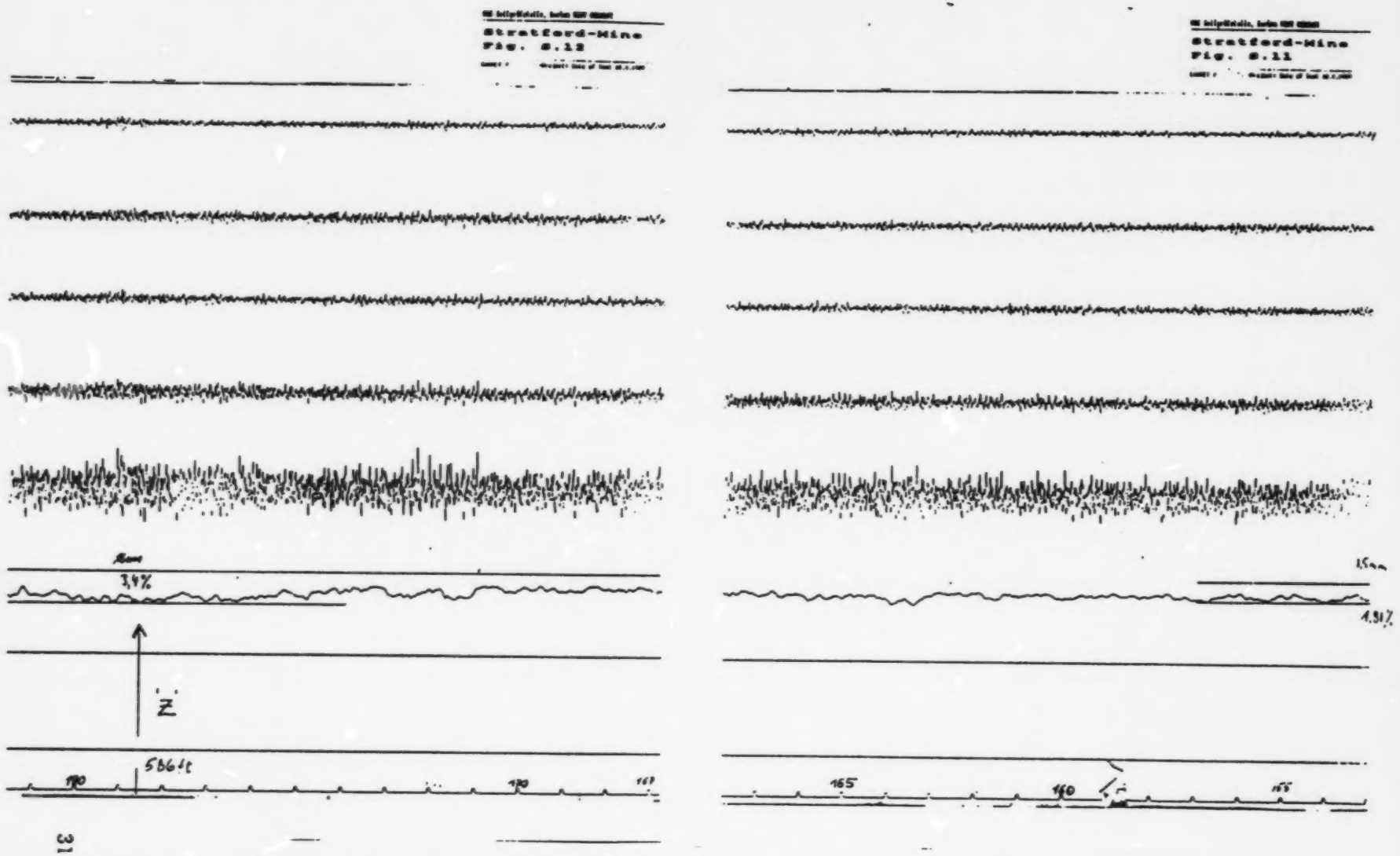

Fig. 4 (continued) — WBK test, in-situ, of 1989 04 07; as reported and reviewed

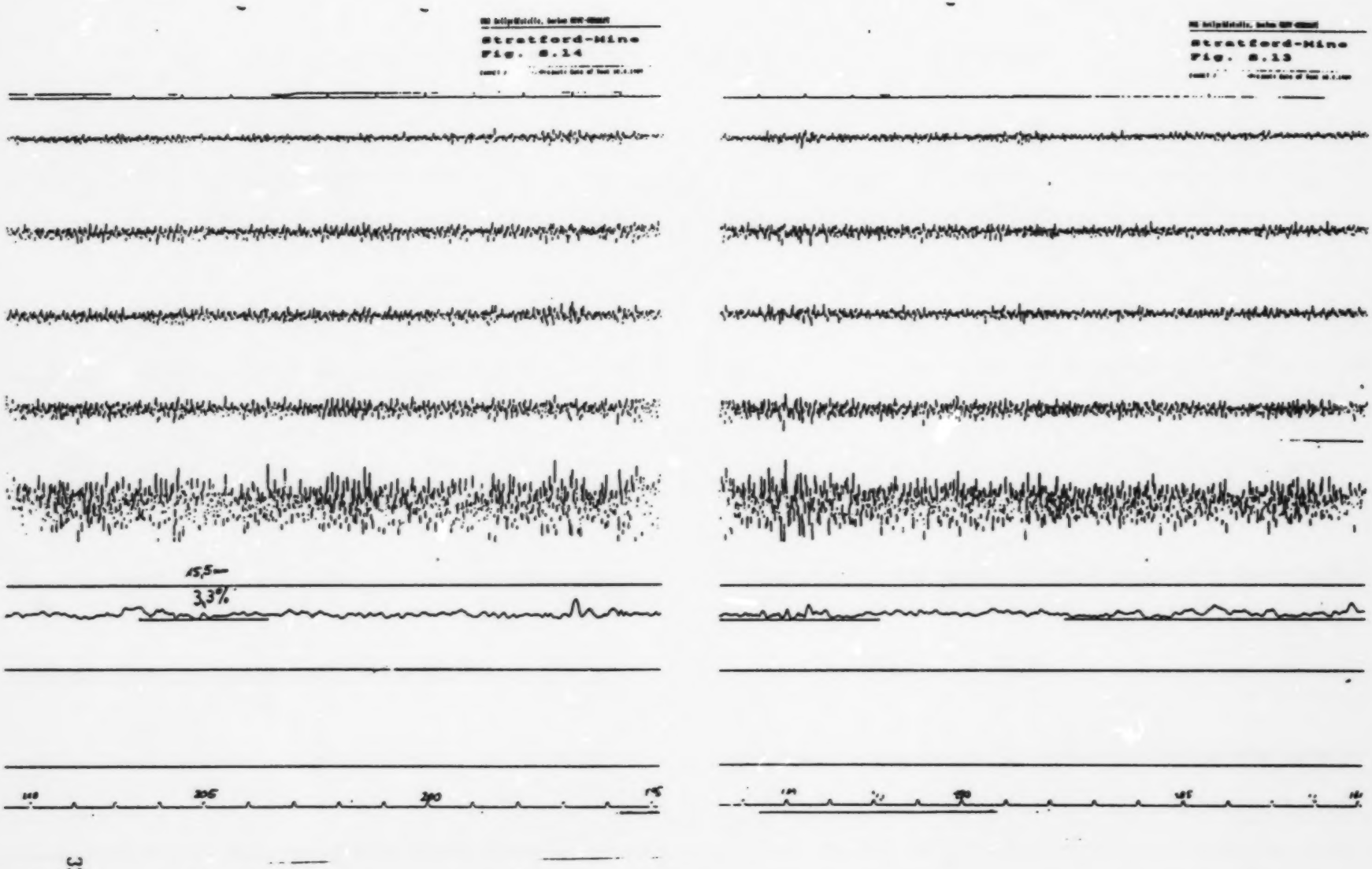

Fig. 4 (continued) — WBK test, in-situ, of 1989 04 07; as reported and reviewed

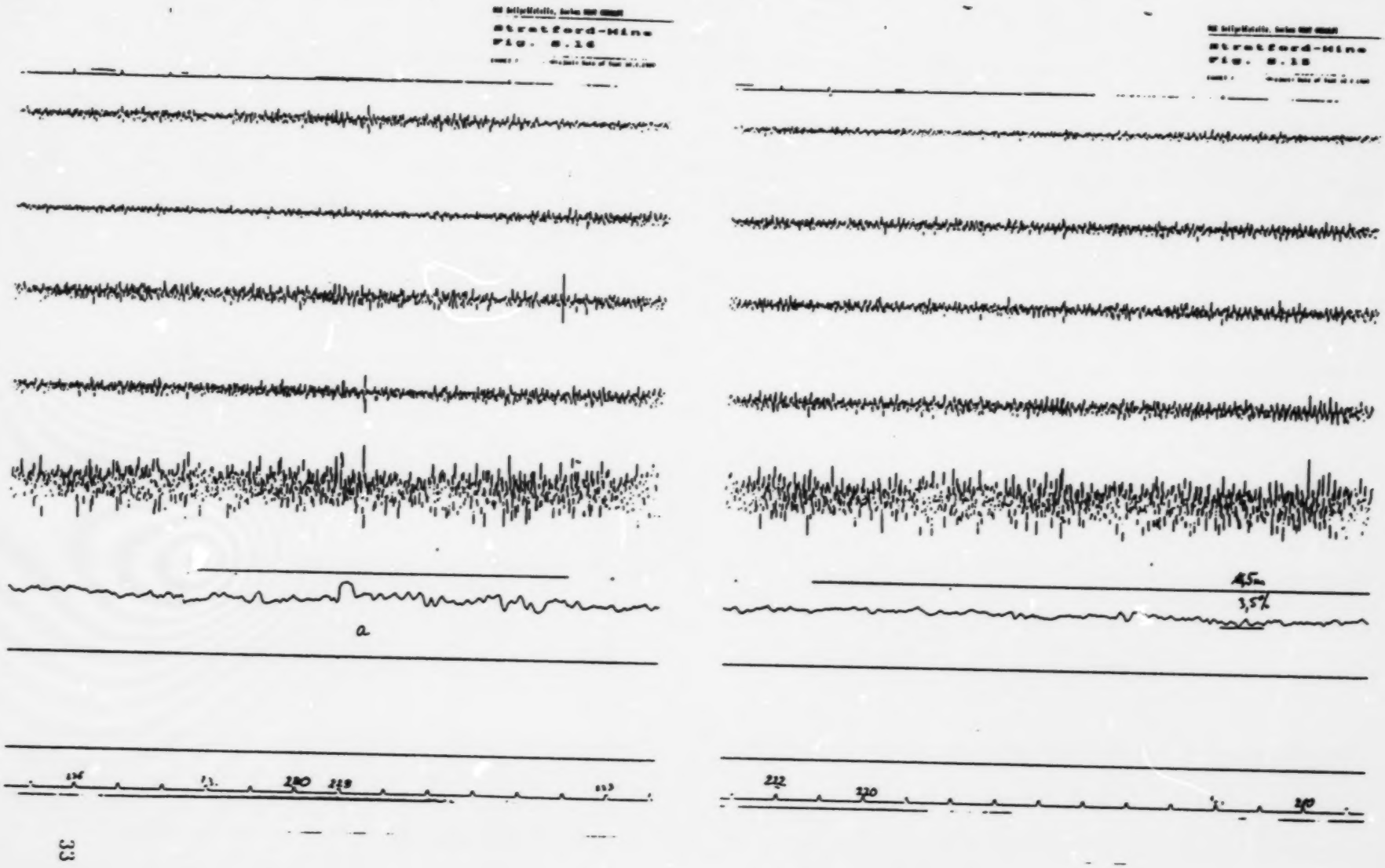

Fig. 4 (continued) — WBK test, in-situ, of 1989 04 07; as reported and reviewed

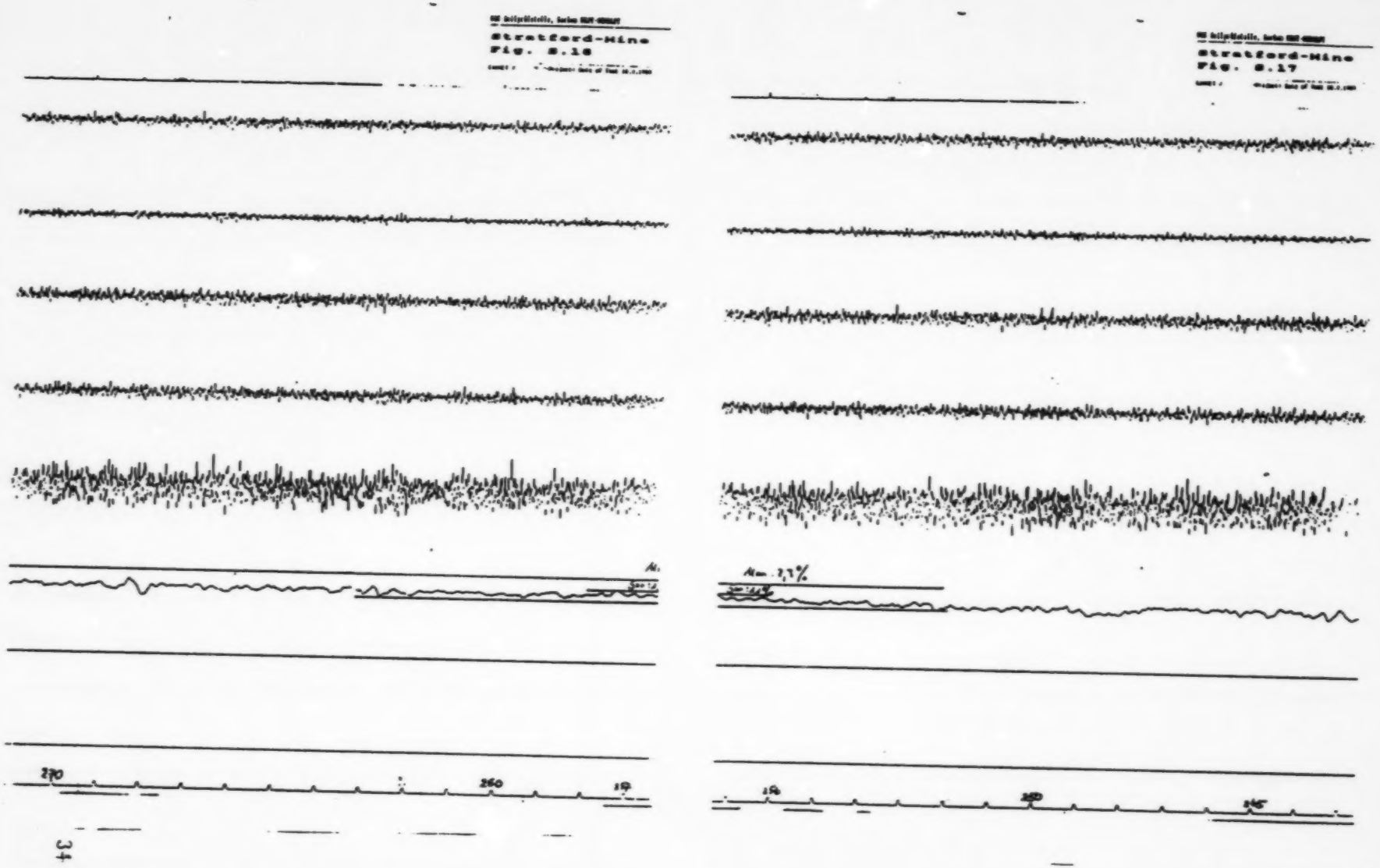

Fig. 4 (continued) — WBK test, in-situ, of 1989 04 07; as reported and reviewed

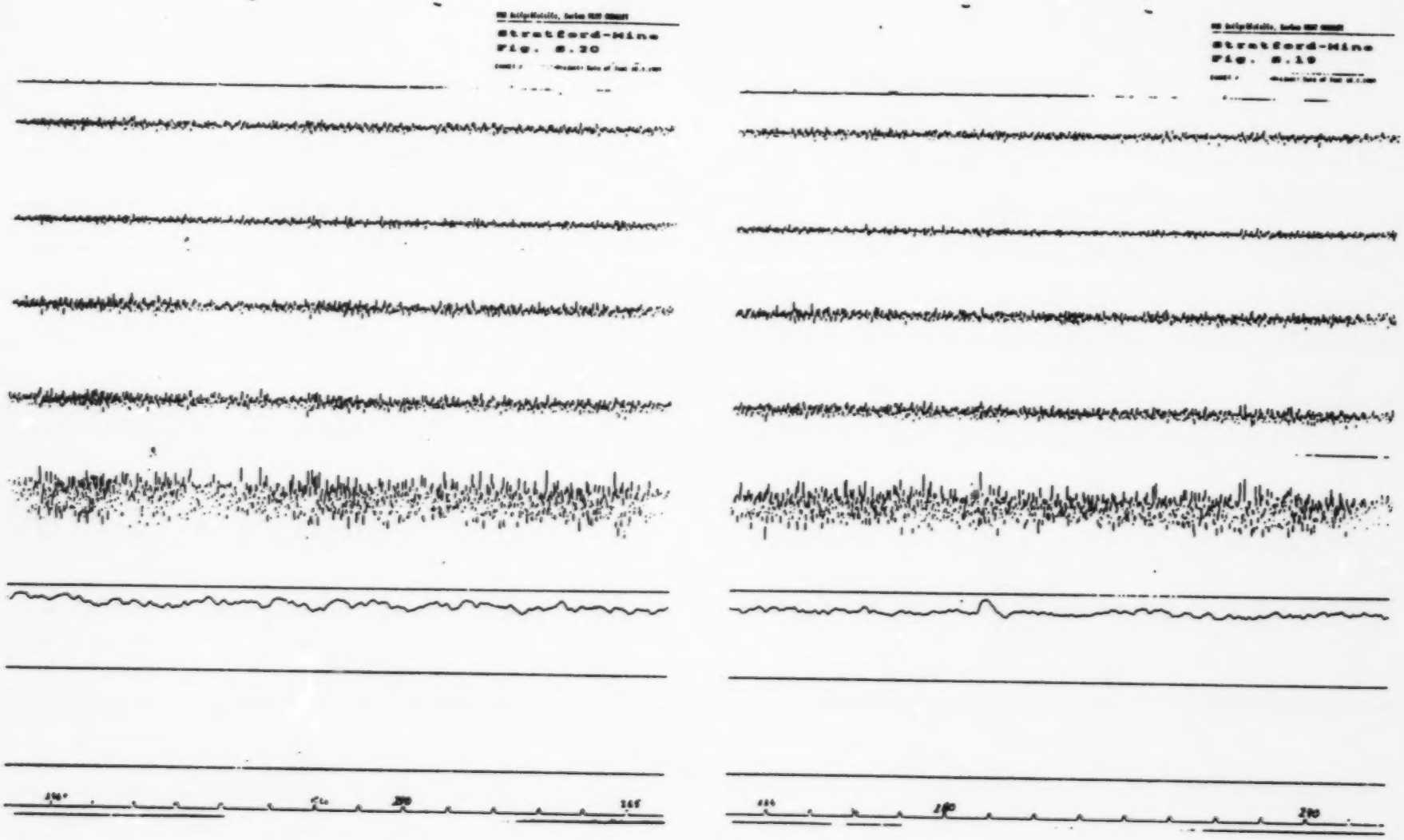

Fig. 4 (continued) — WBK test, in-situ, of 1989 04 07; as reported and reviewed

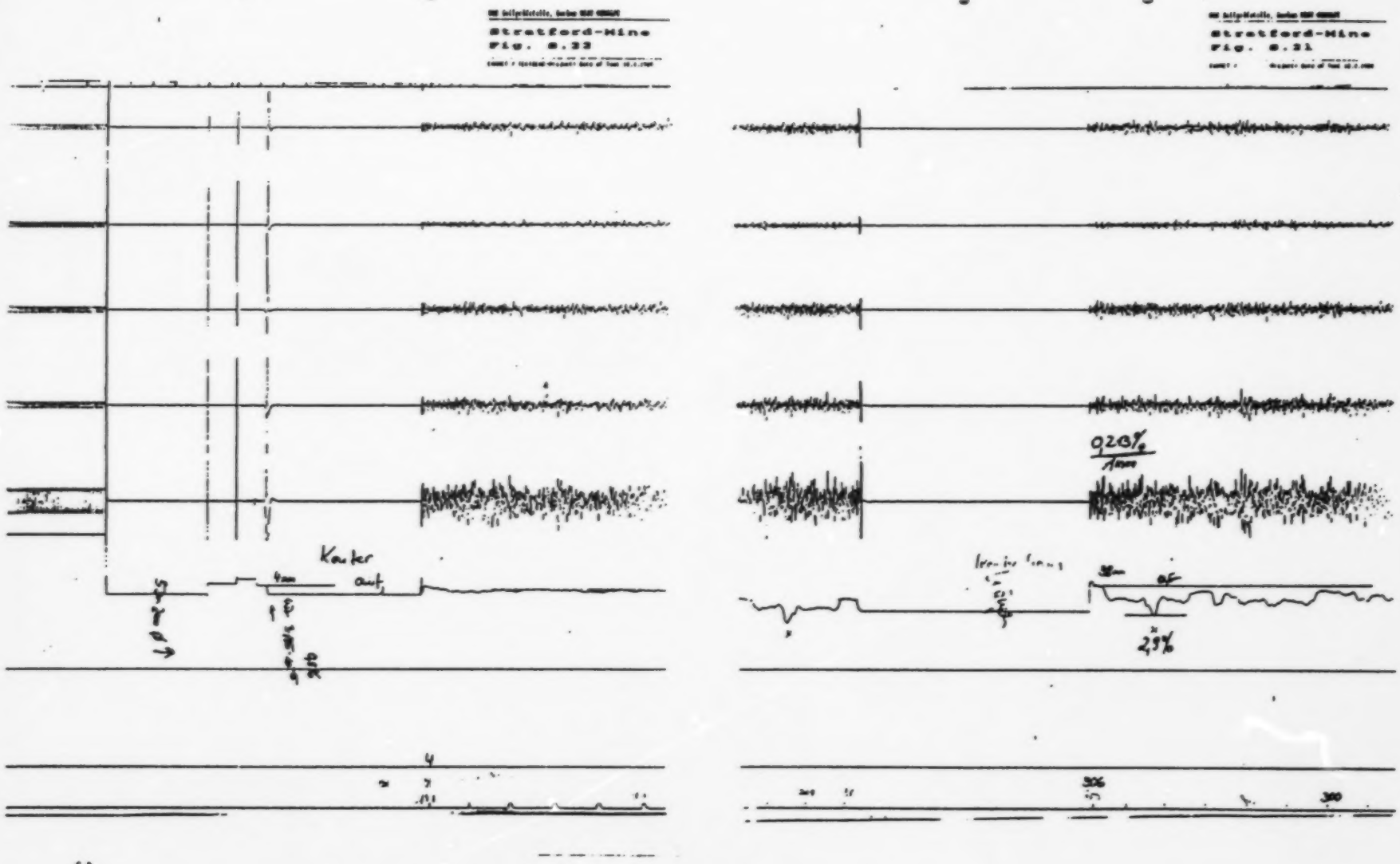

Fig. 4 (continued) — WBK test, in-situ, of 1989 04 07; as reported and reviewed